

What is claimed is:

- 1 1. A power transmission apparatus comprising:
2 an input rotational coupling to which power can be applied from a prime
3 mover and an output rotational coupling by which power can be applied to a
4 load;
5 at least two electric machines, each rotationally connectable relative to
6 one of the input rotational coupling and the output rotational coupling by
7 independently controllable clutch devices, each of the electric machines being
8 independently operable as a motor and as a generator;
9 an electric energy storage device coupled to the electric machines
10 through a controller and operable to store and release electric energy;
11 wherein the controller is coupled to operate the clutch devices and the
12 electric machines in coordination so to obtain a plurality of operational ranges,
13 the ranges differing by routing different subsets of input mechanical and electric
14 power from the prime mover and the energy storage device into charging of the
15 energy storage device and application of power to the output rotational
16 coupling.
- 1 2. The power transmission apparatus of claim 1, wherein the electric
2 machines are mechanically coupled to the input and output rotational couplings
3 by planetary gear sets, and wherein the clutch devices are operable to connect
4 and disconnect rotors of the electric machines relative to elements of the
5 planetary gears.
- 1 3. The power transmission apparatus of claim 1, wherein the input
2 rotational coupling has a normal engine-wise rotational direction for advancing
3 in a given direction, and wherein at least one of said electric machines is
4 movable in the engine-wise direction and in an anti-engine-wise direction during
5 different operational conditions of the apparatus.

1 4. The power transmission apparatus of claim 1, wherein the electric
2 machines comprise first and second motor/generators, each coupled
3 respectively to a first and second planetary gear set.

1 5. The power transmission apparatus of claim 4, further comprising a third
2 planetary gear arrangement having at least two sun gears, coupled to the
3 output rotational coupling.

1 6. The power transmission apparatus of claim 5, wherein the two sun gears
2 of the third planetary gear arrangement are respectively coupleable by the
3 clutch device to planetary gear carriers of the first and second planetary gear
4 sets.

1 7. The power transmission apparatus of claim 6, wherein the third planetary
2 gear arrangement comprises one of a Ravigneaux gear set, a simple-
3 compound gear set configuration, and a plural stage gear set.

1 8. The power transmission apparatus of claim 7, wherein the clutch device
2 comprises selectively operable rotational engagements between first planetary
3 gear set on one hand and on the other hand at least one of the input, a sun
4 gear of the third planetary gear arrangement and a planetary carrier of said third
5 planetary gear arrangement.

1 9. The power transmission apparatus of claim 5, further comprising at least
2 one controllable brake operable to fix an element of third planetary gear
3 arrangement in at least one operational mode of the transmission.

1 10. The power transmission apparatus of claim 9, wherein the controller is
2 operable for selectively operating the clutch device and the brake in a plurality
3 of operational modes including:

4 coupling one of the motor/generators to the input coupling during
5 operation of the prime mover, and operating said one of the motor/generators

6 as a generator for at least one of charging the energy storage device and
7 providing electric power to an other of the motor/generators;

8 coupling at least one of the motor/generators as a motor to the output
9 coupling for operation as a motor adding output power in addition to power from
10 the prime mover under electric power from at least one of the energy storage
11 device and an output of an other of the motor/generators;

12 coupling power from the prime mover to the output coupling exclusive of
13 the motor/generators; and,

14 coupling the output coupling to at least one of the motor/generators for
15 operation as a generator during regenerative braking.

1 11. The power transmission apparatus of claim 10, wherein the operational
2 modes further comprise at least one of:

3 coupling one of the motor/generators to the input coupling during forward
4 operation as a motor powered from the energy storage device, for starting the
5 prime mover;

6 coupling one or both of the motor/generators to the output coupling
7 exclusive of the input shaft, for high torque/low speed operation as a motor
8 powered from the energy storage device;

9 coupling the motor/generators for operation in opposite rotational
10 directions;

11 coupling at least one of the motor/generators to the output coupling for
12 operation in reverse.

1 12. The power transmission apparatus of claim 10, wherein the controller is
2 arranged to shift from one of said operational modes to another in effecting at
3 least one shift for changing at least one of a torque/speed ratio and a
4 charging/discharging condition among the motor/generators and the energy
5 storage device.

1 13. The power transmission apparatus of claim 10, wherein the controller is
2 arranged to effect said shift during one of no-load and synchronous operation of
3 the elements of the clutch device.

1 14. A vehicle in combination with a hybrid transmission, the vehicle
2 comprising an engine and a motor/generator arrangement coupled through a
3 controller to an electric energy storage device, wherein:

4 the hybrid transmission comprises at least one motor/generator, having a
5 rotor coupled to a sun gear of a planetary gear set, said planetary gear set
6 having at least one movable planetary gear carrier and at least one fixable gear;

7 a clutch device comprising a controllable clutch closure coupleable and
8 decoupleable with the planetary gear and the at least one motor generator for
9 achieving alternative operational modes of the transmission;

10 wherein a controller operates the clutch device while switching electric
11 power to and from the motor/generator, for selective control to provide for at
12 least two of engine starting capability, battery charging, regenerative braking
13 during deceleration, alternating driving/generating capability during normal
14 operation, load sharing among the engine, the motor generators and inertia of
15 the vehicle for movement and for charging, and multiple input capability during
16 respective said operational modes.

1 15. The vehicle of claim 14, wherein the transmission has an engine-wise
2 direction corresponding to operation of the engine and wherein the at least one
3 motor/generator is movable in an anti-engine-wise direction in at least one of
4 the operational modes.

1 16. The vehicle of claim 15, further comprising at least a second said
2 motor/generator, wherein the first and second motor/generators are coupled to
3 the transmission by first and second planetary gear sets, and wherein the clutch
4 device has a plurality of separately controllable clutch closures between
5 elements of the planetary gear sets and at least one of a casing, at least one
6 rotating element associated with one of the engine, the motor/generators and

7 driving wheels of the vehicle, for controllable changing among the operational
8 modes.

1 17. The vehicle of claim 14, wherein the alternative connections to the
2 second planetary gear set are made through a third planetary gear
3 arrangement, the third planetary gear arrangement having a planetary carrier
4 that is selectively fixable and releasable by a controllable brake.

1 18. The vehicle of claim 17, wherein the third planetary gear arrangement
2 comprises one of a of a Ravigneaux gear set with plural sun gears and a
3 simple-compound gear set configuration.

1 19. The vehicle of claim 17, wherein the alternative connections to the
2 second planetary gear set are made through a third planetary gear arrangement
3 having a planetary carrier that is selectively fixable to a casing of the
4 transmission by a brake and a ring gear that is rotationally connected to an
5 output shaft associated with driving wheels of the vehicle.

1 20. The vehicle of claim 19, wherein an input shaft of the transmission
2 coupled to the engine, the output shaft associated with the driving wheels, the
3 first and second motor/generators and the first and second planetary gears are
4 all coaxially aligned.